

# Overlooked model uncertainties may misinform forest management strategies

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**Abstract:** Forests play a major role in mitigating climate change, but increasing threats to forests from climate change have heightened the importance of managing these systems. Robust forecasts of forest composition with increasing climate change are critical to this aim, but are currently highly variable. To help guide management in the face of this variability and understand where we can most rapidly reduce uncertainty through improved models, we compare over XX ecological models and climate scenarios in forecasts for forests across Europe. Our approach considers a gradient of more mechanistic (‘process-based’) to correlative models of species distributions to find that uncertainty in ecological models can drive more variation than vastly different climate scenarios (e.g., SSP2 vs. SSP5), but also areas with relatively consistent projections [give overview of these and say that this could reduce uncertainty in how to manage for these areas]. [Maybe something on using existing range data leads to more pessimistic forecasts?] Our results highlight a new way to approach ecological forecasting that better identifies areas of higher certainty and, conversely, the areas where managers will need more diversified approaches and where more ecological study may be most useful.

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## 1 Introduction

Forests are key to pursuing climate mitigation policies and achieving carbon neutrality<sup>1,2</sup>. Yet, they are increasingly under pressure. In Europe, temperatures are rising twice as fast as the global average<sup>3</sup>, and unprecedented pulses of tree mortality have been reported in the last decade<sup>4</sup>. As a result, some European forests are becoming net CO<sub>2</sub> sources<sup>5,6</sup>, due to decreased growth<sup>5,7</sup>, larger burned areas<sup>8,9</sup>, and increased pest- and drought-induced dieback<sup>6,10,11</sup>. Forest managers are facing unprecedented challenges, as they must address current threats while also promoting long-term adaptation to climate change. In this context of high uncertainty, better guidance is needed to implement successful strategies.

Given the diversity of predictive ecological models, the challenge of providing practical insights for forest management is even greater. Different models, ranging from correlative to more mechanistic approaches, may provide highly divergent projections. While it remains unclear under which conditions one approach is more reliable than another, most forecasting studies still rely on a limited set of models. We thus often lack a comprehensive understanding of what drives differences between projections. Given the urgency of climate change, we must incorporate this diversity and merge across ecological and climatological models to provide a complete picture of both the threats and opportunities for forests. Failing to do so could ultimately compromise the success of forest management decisions.

Gaining a better understanding of where uncertainties originate and how they relate is crucial to identify opportunities for model developments<sup>23</sup> and to address policy-relevant questions<sup>24</sup>. Forest managers need to know whether the current species will be able to tolerate future climate

<sup>22</sup> conditions, whether they can rely on its natural regeneration, or whether they should capitalize  
<sup>23</sup> on new species opportunities.

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